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04 May 2023

Phosphate glass fibrous scaffolds: tailoring of the properties and improvement of the bioactivity through the incorporation of mesoporous glasses

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Introduction

Synthetic bone **scaffolds** are proposed as an alternative to the use of bone grafting technique for bone regeneration. Porous scaffold obtained from cutting glass fibres and randomly arranging into a mould, shows the **open porosity** necessary for tissue ingrowth and vascularization. Moreover the use of a **resorbable glass** and **mesoporous bioactive particles** (*i.e.* specific surface area up to 800 m^2/g, adjustable pore size between 2 and 50 nm, large pore volume [1]) allows to obtain a 3D structure in which the newly regenerated bone substitutes the synthetic material.

Materials and methods

Phosphate glass fibers

TiPS2.5

Fibres of a TiO2-containing phosphate glass fabricated following the preform drawing approach [2].

Bioactive powder

CEL2

Dense silica-based bioactive glass ($45SiO_2$, $3P_2O_5$, 26CaO, 7MgO, $15Na_2O$, $4K_2O$ mol.%) produced by melt quenching technique [3].

SD_MBG

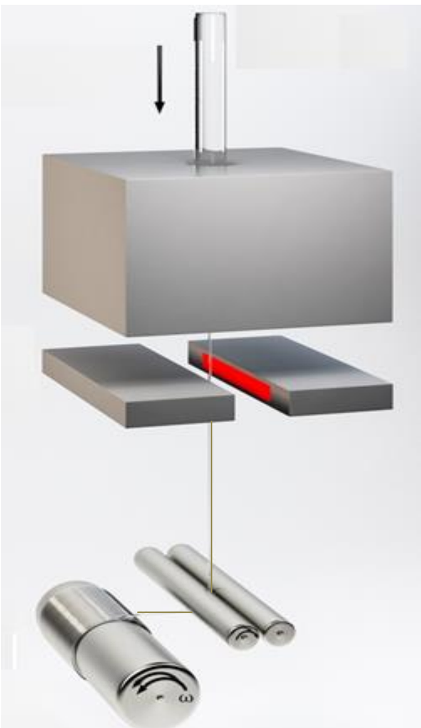
Micro-sized mesoporous glass based on SiO_2-CaO ($80SiO_2$, 20 CaO mol.%) system produced by an aerosol-assisted spray-drying technique [4].

Cu_BGn2%

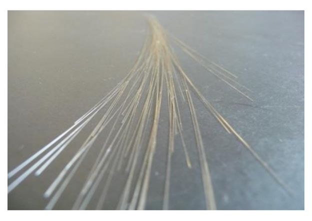
Cu-containing mesoporous glass nanoparticles ($85SiO_2$, 13 CaO, 2CuO mol.%) synthetized by an ultra-sound assisted sol-gel method.

Scaffold preparation

FIBRE DRAWING

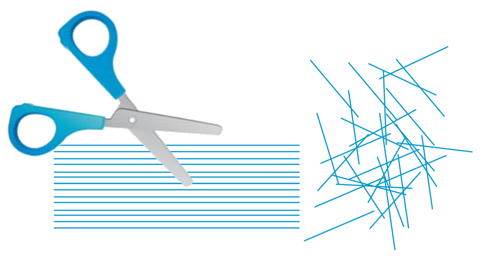


Ɵ 110 µm

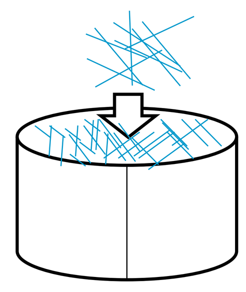


CUTTING

L= 3 mm, 6 mm

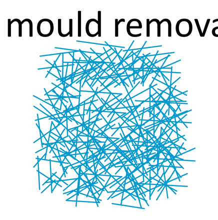


SHAPING

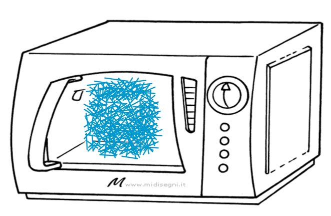


(D 13mm, h 12 mm)

The structure shape is maintained after mould removal

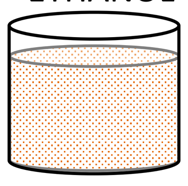


SINTERING



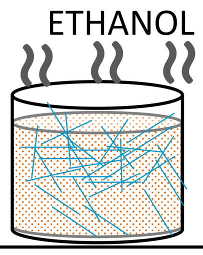
ADDITIONAL STEP: INTRODUCTION OF THE BIOACTIVE POWDER

SUSPENSION OF BIOACTIVE POWDER IN ETHANOL



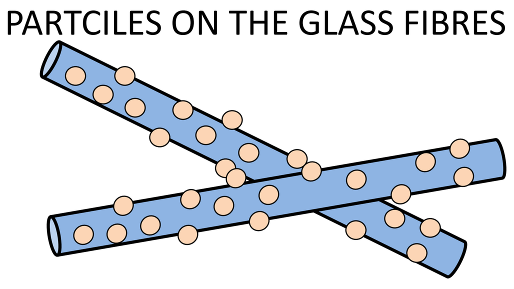
Ultrasound treatment l

EVAPORATION OF ETHANOL



≈50° C

DEPOSITION OF THE BIOACTIVE PARTCILES ON THE GLASS FIBRES



Mesoporous Powder characterization

Structural analysis: N_2 adsorption/desorption technique

Morphological analysis: FESEM

Scaffold characterization

Morphological analysis: FESEM

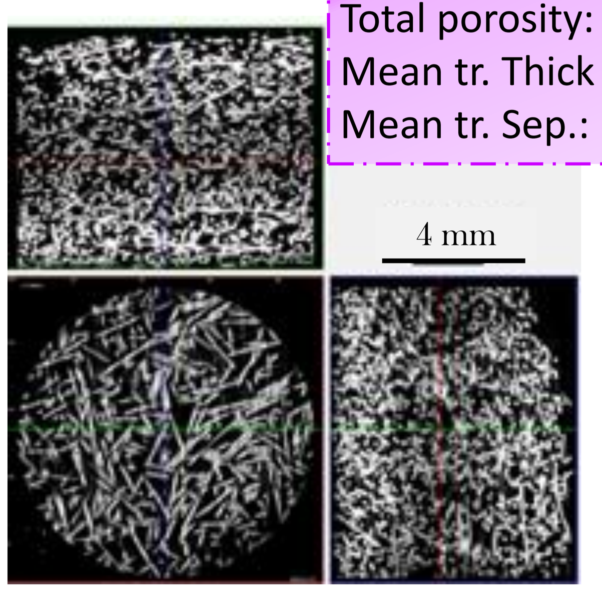
Inner structure: Micro-CT

Scaffold bioactivity: SBF soaking test

Results and discussion

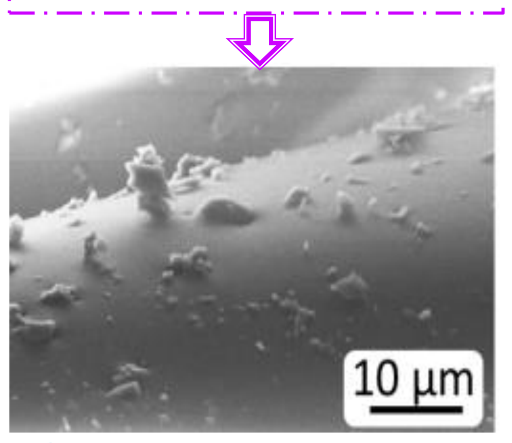
S110_CEL2

- 3 wt.% bioactive powder
- Fibres: 3 mm



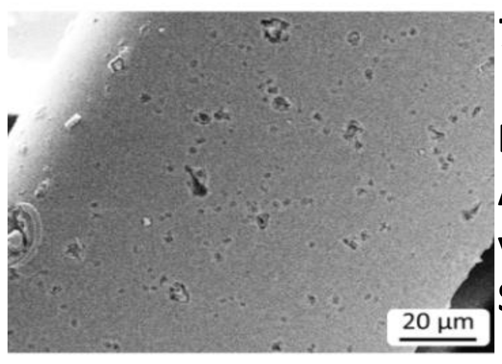
Total porosity: 58%
Mean tr. Thick :111 µm
Mean tr. Sep.: 162 µm

CEL2 are not well incorporated on fibre surface.



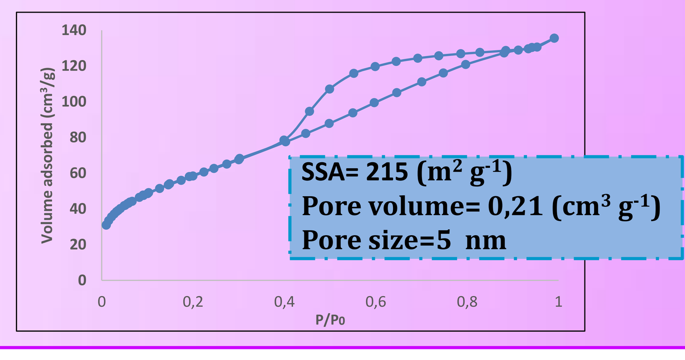
Bioactivity test in SBF

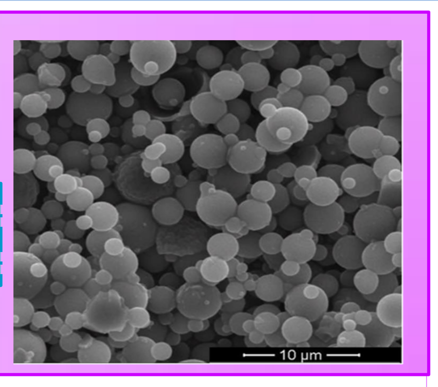
Only few particles still anchored to the scaffold



7 DAYS

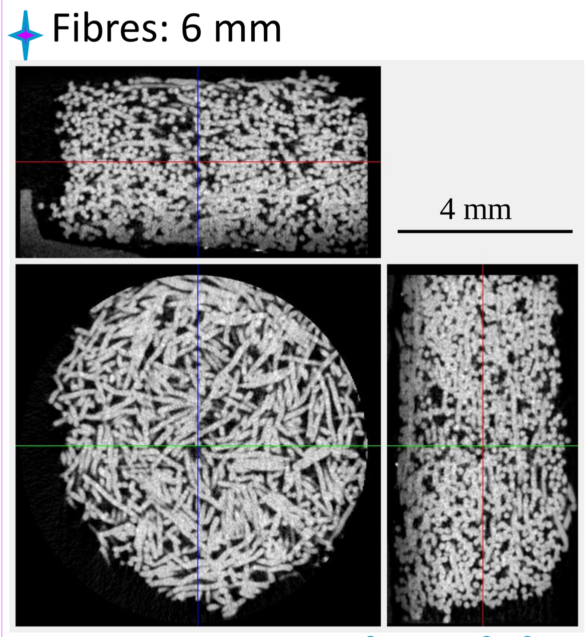
MBG



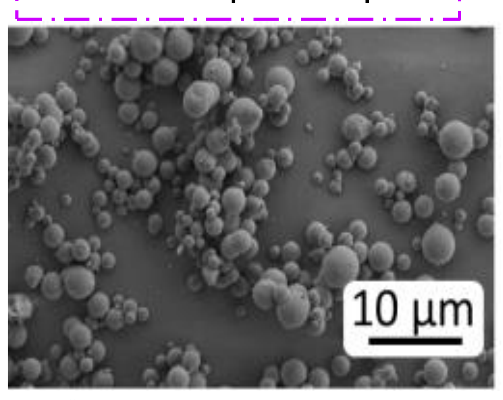


S110_MBG

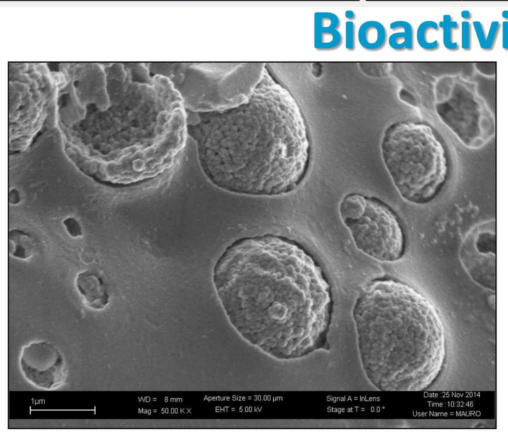
- 5 wt.% bioactive powder
- Fibres: 6 mm



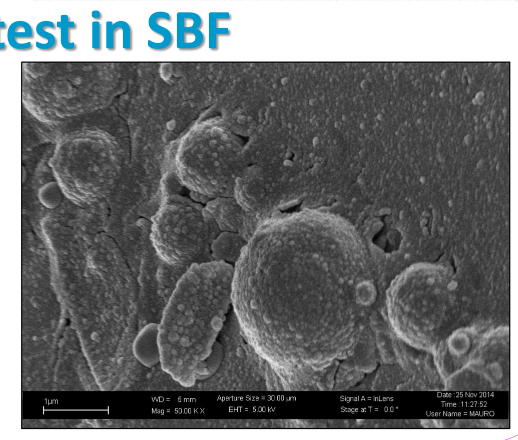
Total porosity: 53%
Mean tr. Thick :159 µm
Mean tr. Sep.: 203 µm



Bioactivity test in SBF

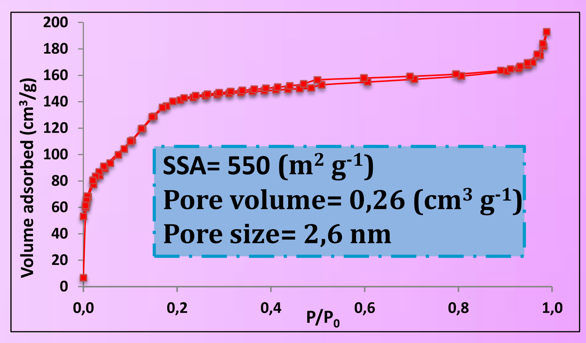


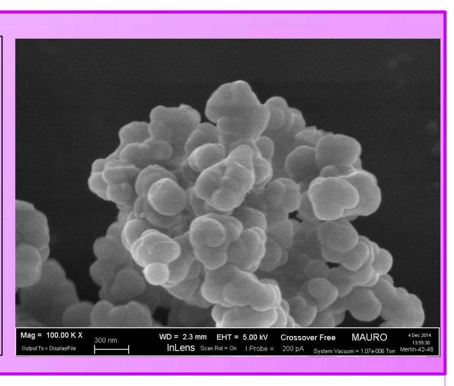
1 DAy



2 DAYS

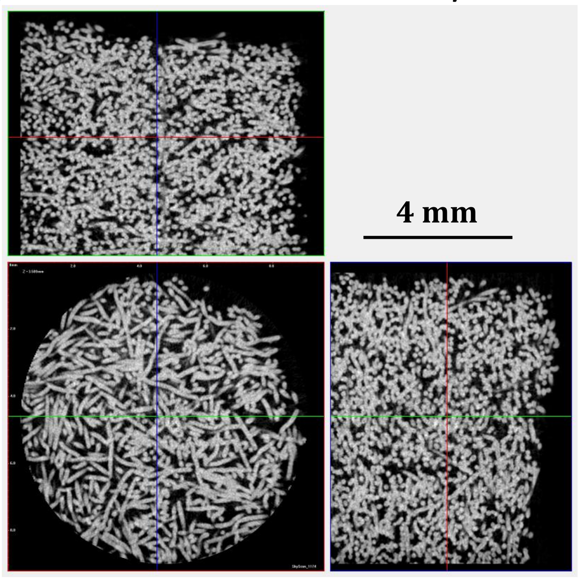
Cu_BGn2%



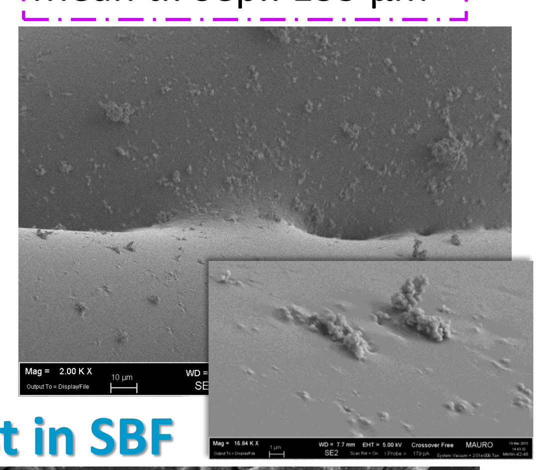


S110_Cu_BGn2%

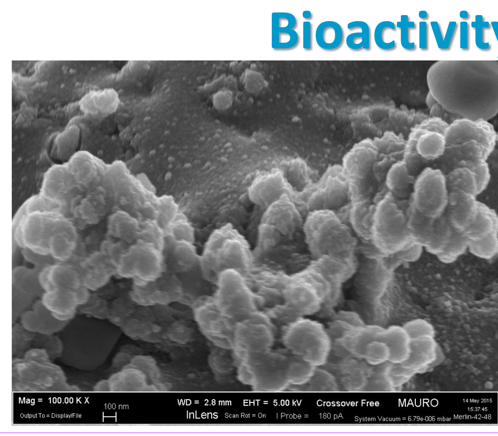
- 0.5 wt.% bioactive powder
- Fibres: 70% 3mm fibres / 30% 6mm fibres



Total porosity: 33%
Mean tr. Thick :170 µm
Mean tr. Sep.: 133 µm



Bioactivity test in SBF



1 DAy

2 DAYS

Acknowlegement

The activity leading to this review has received funding from H2020-NMP-PILOTS-2015 under grant agreement no. 685872 (MOZART).

References

[1] D. Arcos et al. Chem Mater, 21 (2009), 1000–1009
[2] C. Vitale-Brovarone et al. Mat Sci Eng C 31 (2) (2011) 434–442
[3] Vitale Brovarone et al. Acta Biomater 3 (2007) 199–208
[4] Vitale Brovarone et al. Key Engineering Materials Vol. 631 (2015) pp 43-47

Conclusion

The incorporation of **MBG and Cu_BGn2% powder** in the **phosphate glass fibrous scaffold** resulted to be a very interesting strategy to induce hydroxyapatite formation on the scaffold. Their fast bioactive response is due to their **mesoporosity**: it involves a high surface area available for ion exchange which is responsible for the glass bioactivity

These promising results encourage further investigation in order to fully exploit the ability of mesoporous particles to act as a system for **smart release of therapeutic ions and drugs**.